INDOOR AIR QUALITY ASSESSMENT

Bradstreet School
70 Main Street
North Andover, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Paul Szymanski, Director of Management Support Services for the North Andover Public Schools, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at Bradstreet School in North Andover, Massachusetts. On March 28, 2002, a visit was made to this building by Cory Holmes and Suzan Donahue, of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program, to conduct an indoor air quality assessment. BEHA staff were accompanied by Kathleen Callagy, Principal of Bradstreet School, during the assessment.

The Bradstreet School is a two-story, red brick building with a basement constructed in 1911. An addition was built to the rear of the building in 1948. A modular classroom unit was added in 1989, which currently serves as the school library (see Picture 1). Principal Callagy reported that the roof and mechanical supply and exhaust ventilation were replaced during 1999-2000. The second floor consists of general classrooms. The first floor contains general classrooms, library and school offices. The basement is made up of an all-purpose room, which serves as the gym and cafeteria, a kitchen and boiler room. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a kindergarten population of approximately 275 divided into two sessions, morning and afternoon. Approximately 20 individuals staff the school. Tests were taken under normal operating conditions at the school and results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that the carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, with one exception, indicating adequate air exchange by the ventilation system in most areas. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 2). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 3) and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. All univents were operable during the assessment. Obstructions to airflow, such as items placed in front of univent returns, were seen in a few classrooms (see Picture 4). To function as designed, univents and univent returns must remain free of obstructions.

Mechanical exhaust ventilation is provided by wall-mounted intake grills connected to chimneys capped with exhaust fans (see Pictures 5 & 6). All exhaust vents were operating during the assessment. As with the univents, a number of exhaust vents were obstructed by tables, chairs, boxes and other items (see Picture 7).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be

balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997, BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself at levels measured in this building. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix 1 of this assessment.

Temperature readings ranged from 69 ^{0}F to 76 ^{0}F, which were very close to BEHA's recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{0}F to 78 ^{0}F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 19 to 27 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A few rooms had water-stained ceiling tiles, which are evidence of historic roof or plumbing leaks. Water-damaged ceiling tiles can provide a source of microbial growth and should be replaced after a water leak is discovered. No standing water was observed on the roof and no active roof leaks were reported to BEHA staff during the assessment.

Several classrooms had a number of plants, all of which appeared to be equipped with drip pans. Moistened plant soil and drip pans can serve as a source of mold growth. Over-watering of plants should be avoided and staff should ensure that plants are located away from univents to prevent the aerosolization of dirt, pollen or mold.

Modular Classroom

The modular classroom was examined. Guidance concerning prevention of mold growth was provided to the North Andover School Department in relation to a different

school facility in March 2002. According to this guidance, the following general improvements can be made to avoid microbial growth within these structures:

1. Use of sloped roof with properly installed gutter and downspout system to drain rainwater.
2. Siting the structure on a well-drained surface.
3. Surface run-off should be directed away from the structure.
4. The crawlspace under the structure should be well ventilated.
5. Check all caulking and/or flashing around windows and service posts, especially after moving a structure.
6. Maintain ventilation according to American Society for Heating, Refrigerating and Air-conditioning Engineers (Stewart, B., 2002).

The following section provides an evaluation of the Bradstreet modular unit using these issues as a basis for evaluation.

The exterior walls of the rear modular unit appeared to be intact. Drainage for this unit appears to be adequate. A downspout and gutter system exists for portions of this unit, which can allow for water on the roof to splash on the tarmac and wet the exterior wall of the modular in several areas. In addition, one of the downspouts ends several inches above the ground, which can allow water to accumulate near the exterior wall of the modular (see Picture 8). Under these circumstances, continued water exposure to the exterior walls may result in damage to the modular building in the future. There are minimal means for ventilating the crawlspace under this structure.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile

organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

The teacher's workroom contained several lamination machines, a photocopier and a mimeograph machine. Lamination machines can produce irritating odors during use. Mimeograph duplicating fluid contains methanol (methyl alcohol), which is a volatile organic compound that readily evaporates at room temperature. The off gassing of this material can be irritating to the eyes, nose and throat. Methanol is also a highly flammable material, which can be ignited by either flame or electrical source. This area was not equipped with mechanical exhaust ventilation. Without mechanical exhaust ventilation, pollutants produced by office equipment can build up and become a potential source of irritation to the eyes, nose and respiratory system.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. Items should be relocated and/or cleaned periodically to avoid excessive dust build-up. A number of exhaust and return vents in classrooms, restrooms and in the all-purpose room were noted with accumulated dust (see Picture 9). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

The univent in classroom 10 was opened to examine the conditions of filters. BEHA staff noted a dark oily stain (e.g. hydraulic fluid) on the filter, which suggests a possible leak/malfunction of the pneumatic system (see Picture 10). The filter was also coated with

dirt/dust and accumulated material (see Picture 11). A debris-saturated filter can obstruct airflow and may serve as a reservoir of particulates that can be re-aerosolized and distributed to occupied areas via the ventilation system.

A missing ceiling tile with exposed fiberglass was observed in the all-purpose room (see Picture 12). Aerosolized dust, particulates and fiberglass can provide a source of eye, skin and respiratory irritation to certain individuals. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving, and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made to improve general indoor air quality:

Main Building

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy.
2. Examine univent in classroom 10 for proper function and repair if necessary.
3. Consider having the systems balanced by an HVAC engineering firm every five years in accordance with SMACNA guidelines.
4. Remove all obstructions from univents and mechanical exhaust vents to facilitate airflow.
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

6. Repair any existing water leaks and replace any remaining water-stained ceiling tiles. Examine the areas above these tiles for microbial growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.
7. Ensure plants are located away from univents in classrooms. Ensure drip pans are placed underneath plants in classrooms. Examine drip pans periodically for microbial growth and disinfect with an appropriate antimicrobial where necessary.
8. Install local exhaust fans in teacher's workroom or consider relocating odor-generating office equipment to an area equipped with local exhaust ventilation.
9. Replace missing ceiling tile in all-purpose room. Consider reattaching physical therapy equipment on an as-needed basis.
10. Change univent filters as per the manufacturer's instructions or more frequently if needed.
11. Clean univent return vents and exhaust vents periodically of accumulated dust.

Modular Unit

1. Consider installing gutters/downspouts in areas without them to drain water from the roof. This will allow the delivery of water to the tarmac in a manner which prevents splashing or moistening of the exterior wall. Extending downspouts to ground level to direct water away from the base of the exterior wall of the modular classroom is also advised.
2. Improve ventilation of crawlspace beneath modular unit by installing large passive air vents. If this is done, ensure that the underflooring is sufficiently insulated.

3. Set the thermostat for this classroom to the fan “on” position to operate the ventilation system continuously during the school day.

References

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

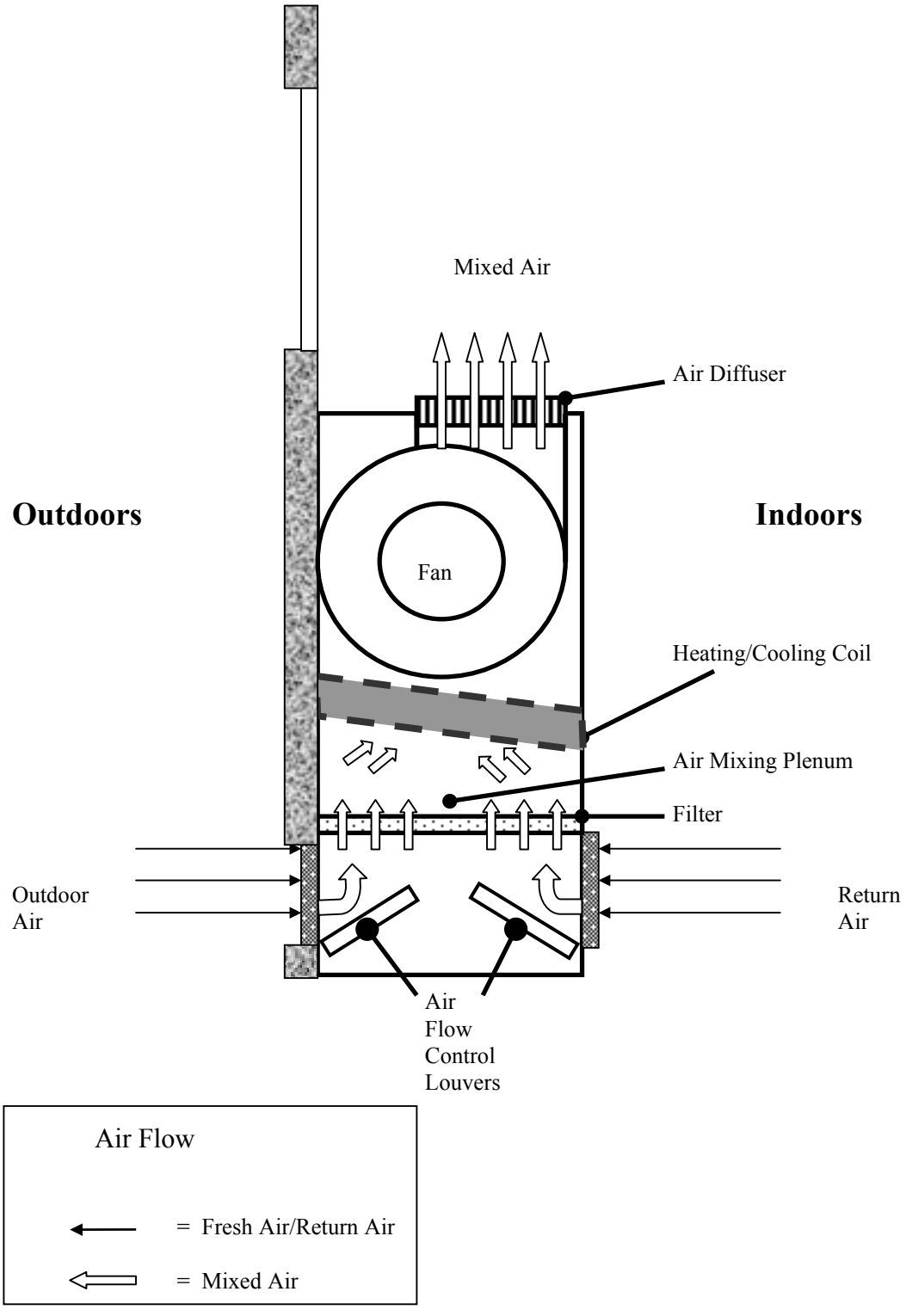
Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

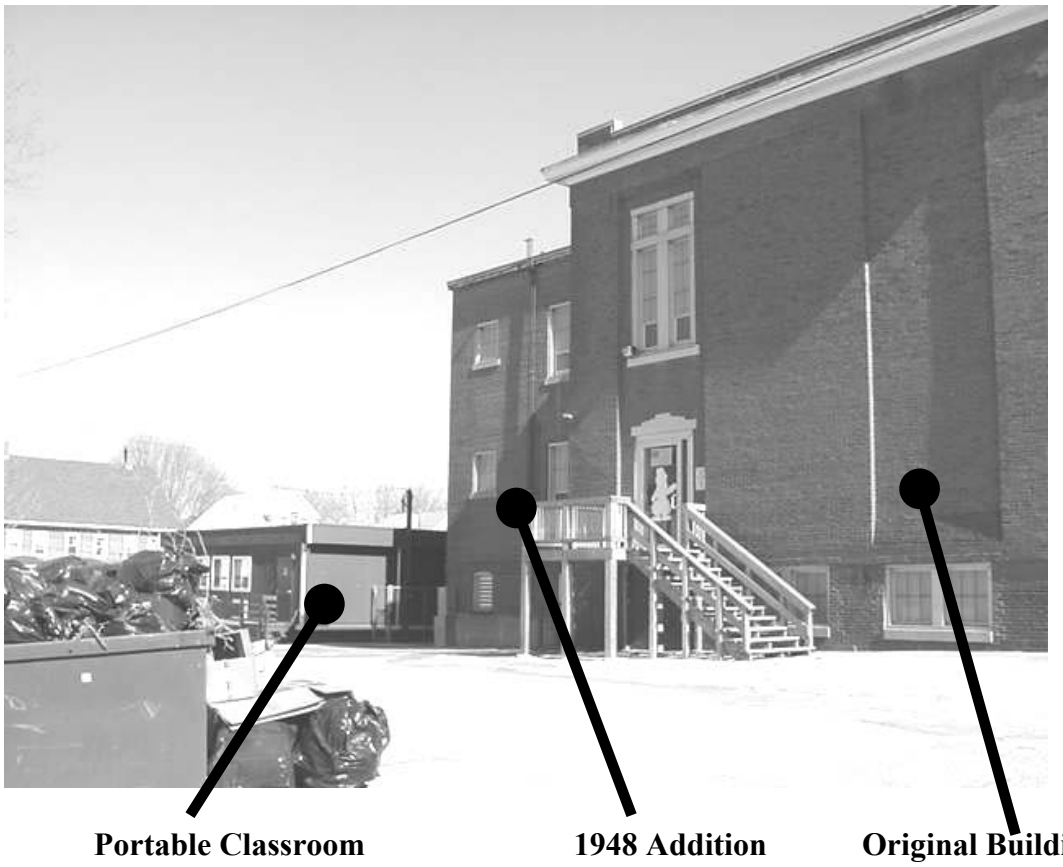
SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Stewart, B. 2002. Preventing Mold Growth in Temporary School Structures. Modular Building Institute, Charlottesville, VA. March 2002. http://www.mbinet.org/web/magazine/mold01_02.html?style=printable .

Figure 1 **Unit Ventilator (Univent)**



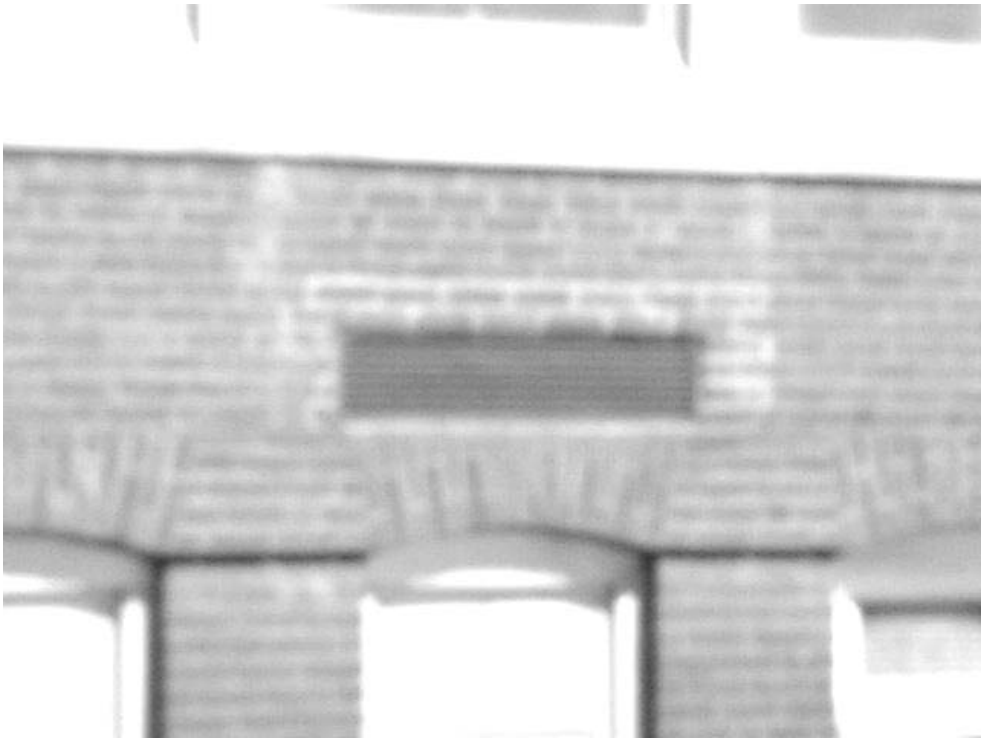
Picture 1



Picture 2

Classroom Univent

Picture 3



Univent Fresh Air Intake

Picture 4

Univent Airflow Obstructed by Classroom Furniture

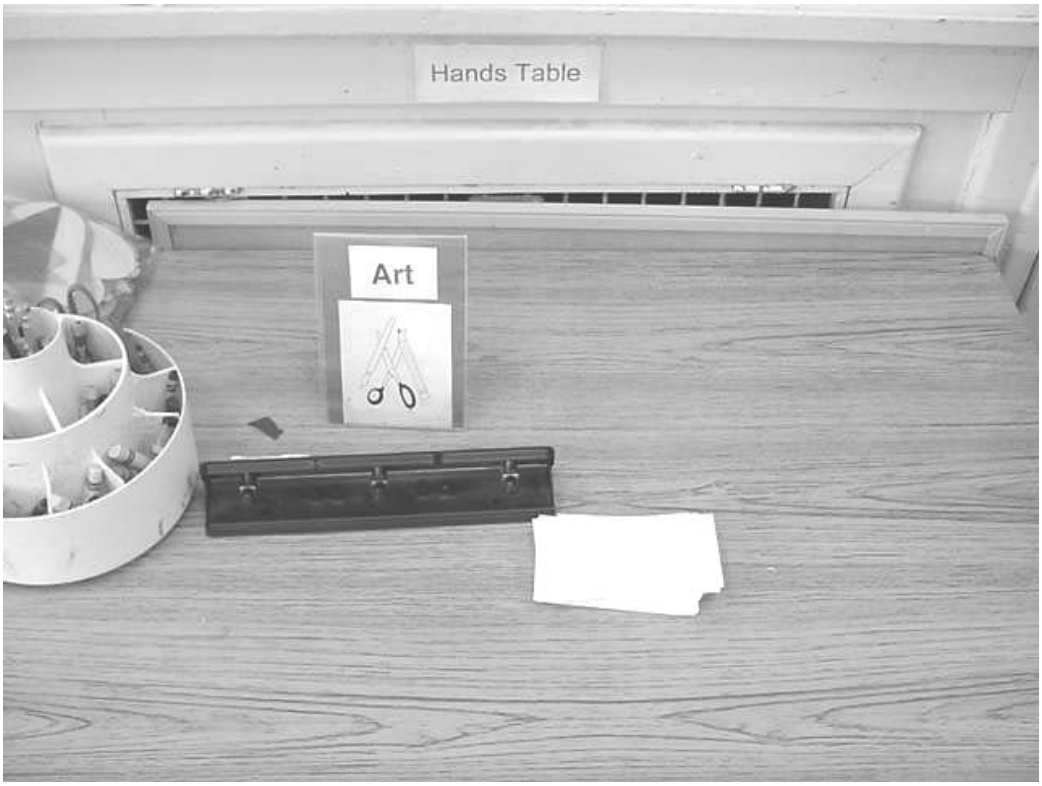
Picture 5

Classroom Exhaust Vent Connected to Chimney

Picture 6

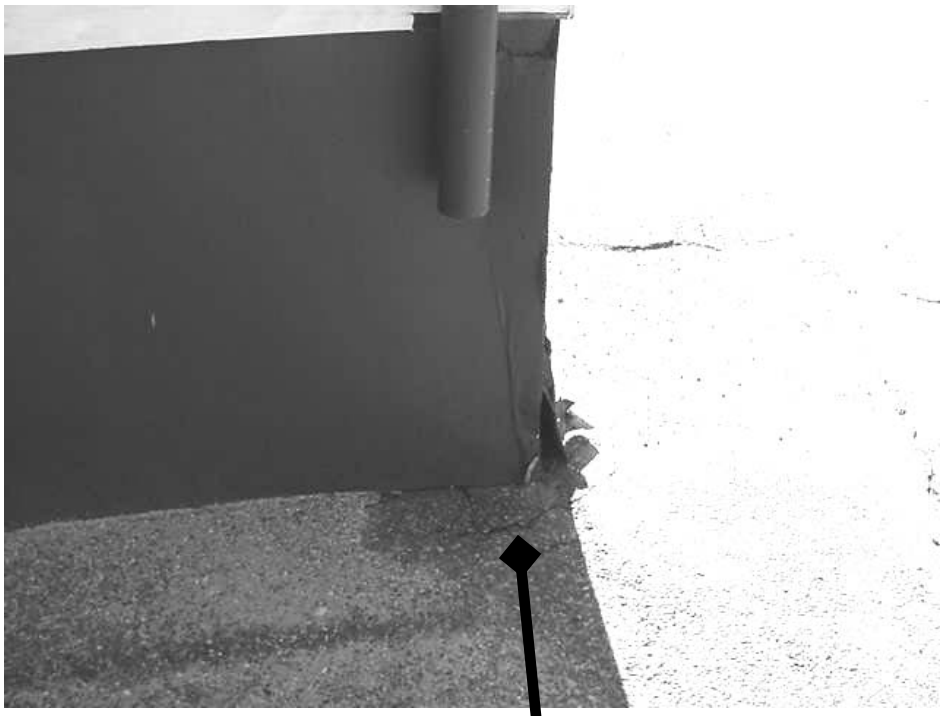
Chimneys Capped With Exhaust Motors

Picture 7



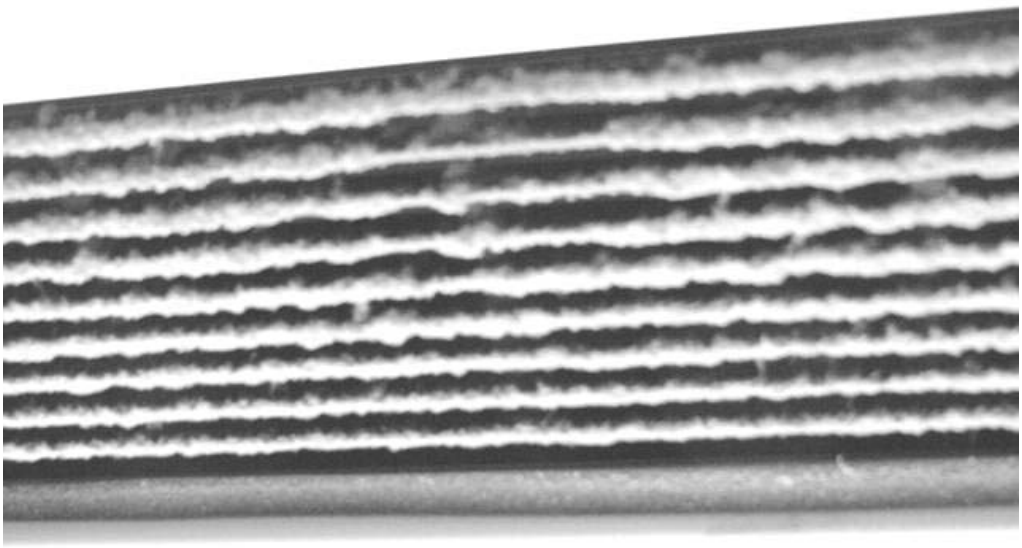
Exhaust Grate Obstructed by Classroom Furniture

Picture 8



Downspout for Modular Classroom – Note Water Damage from Splashing

Picture 9

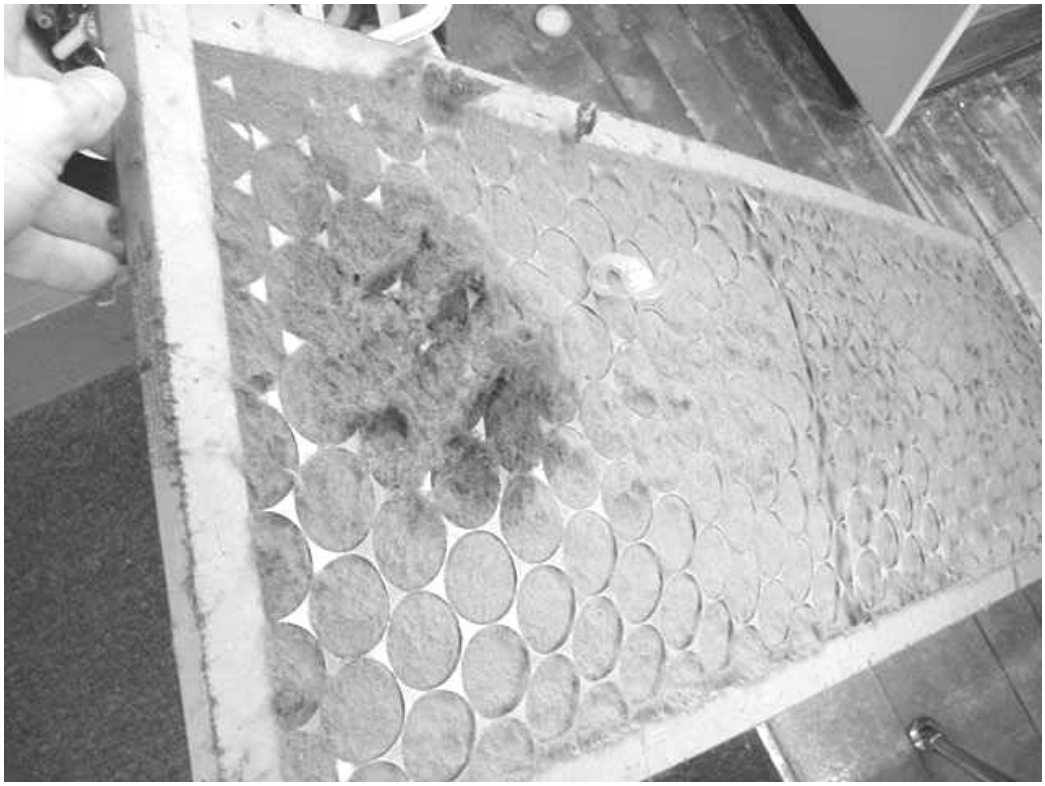


Accumulated Dust on Univent Return Vent

Picture 10

Univent Filter Stained With Oily Substance

Picture 11



Dirty Classroom Univent Filter

Picture 12

Missing Ceiling Tile and Exposed Fiberglass in All-Purpose Room

TABLE 1

Indoor Air Test Results – Bradstreet Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	305	44	49					
Guidance Office	609	75	25	0	Yes	No	No	Carpet
Nurse's Office	776	75	24	1	Yes	No	Yes	Exhaust vent in adjacent restroom, carpet
Room 4	906	75	24	14	Yes	Yes	Yes	Exhaust vent obstructed, 2 doors open, 10 plants, partial carpet
Room 5	713	72	23	18	Yes	Yes	Yes	Exhaust obstructed, computers, accumulated items, door open
Secretary's Office	501	72	21	1	Yes	No	Yes	Window and door open, exhaust vent in adjacent restroom, window-mounted air conditioner, carpet, photocopier, dry erase board
Room 2	628	71	24	22	Yes	Yes	Yes	Exhaust obstructed, carpet, door open, missing CT-exposed fiberglass
Library	703	73	27	1	Yes	Yes	No	~10 occupants gone <5 min., carpet, water-stained CT, modular classroom

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Bradstreet Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Teachers' Workroom	633	73	25	0	Yes	No	No	Photocopier, lamination machine, mimeograph, 2 water-damaged CT
Bear Stop Office	551	73	23	2	No	No	No	Spray cleaner, exposed fiberglass, door open
Room 8	720	75	22	5	Yes	Yes	Yes	Aquarium, plant, tennis balls
Room 5	637	74	21	22	Yes	Yes	Yes	Door open, cleaning product-in reach of students
Room 6	774	73	22	21	Yes	Yes	Yes	Door open
Room 7	631	73	21	22	Yes	Yes	Yes	Exhaust vent obstructed, door open, 3 water-damaged CT
Room 3	427	69	21	0	Yes	Yes	Yes	Window open, univent blocked on 3 sides, exhaust vent blocked
Room 10	428	69	22	0	Yes	Yes	Yes	Exhaust vent partially blocked, univent opened-hydraulic fluid leak-filter occluded with dirt/dust
Activity Room	529	73	20	~20	Yes	Yes	Yes	Missing CT-exposed fiberglass, dust accumulation on exhaust vent/univent return
Teachers' Room	425	74	19	1	Yes	Yes	Yes	Exposed fiberglass around pipes

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Bradstreet Elementary School, North Andover, MA – March 28, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Meeting Room	456	76	19	0	No		Yes	Exposed fiberglass around pipes

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%